TECHNICAL PROGRESS REPORT NO. 137 JANUARY 1963

# Sucrose as a Gelation Inhibitor of Commercially Frozen Papaya Puree

HARRY Y. YAMAMOTO
and
WINFRED INOUYE

HAWAII AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF HAWAII

HAWAII AGRICULTURAL EXPERIMENT STATION
COLLEGE OF TROPICAL AGRICULTURE
UNIVERSITY OF HAWAII
Honolulu, Hawaii

# Sucrose as a Gelation Inhibitor of Commercially Frozen Papaya Puree

**HARRY Y. YAMAMOTO***

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**WINFRED INOUYE** †

## INTRODUCTION

Commercial freezing of papaya puree is used as a holding operation or as a means for transshipping the puree to the Mainland. After thawing, the frozen puree is then used for blending with other juices or in jam manufacturing. Papaya puree, however, gels upon standing or after being frozen and subsequently thawed. The industry has long been faced with this problem of gelling. Additional equipment, time, and labor are required to mechanically break up the gel.

The use of heat or pectin-degrading enzymes as practical means of preventing gelation has been investigated *(2)*. The use of heat is an effective means for preventing gel formation; however, in order to avoid

*Assistant Food Technologist, Hawaii Agricultural Experiment Station.

†Apprentice, National Science Foundation Hawaii Junior Science Apprenticeships program, 1962, University of Hawaii.

undesirable heat damage to the puree, i.e., off-odors and off-flavors, it is imperative that the heating and cooling cycles be rapid. The cost of equipment suitable for this purpose is often prohibitive for the small processor.

The use of commercial polygalacturonase preparation is a simple and effective means of preventing gelation. The equipment requirements are minimal. However, the fact that the papaya pectins are degraded and the polygalacturonase remains active until heat-inactivated, places certain limitations on its use.

The use of either heat or polygalacturonase, therefore, is effective in preventing gelation, within the limitations discussed. In the commercial use of frozen papaya puree, the inhibiting of gelation until such time as the puree is reprocessed may be sufficient, in certain processing operations. If gelation could be inhibited to such a degree that the thawed product was either fluid or an easily dispersed gel, there would then result a significant improvement in time and effort expanded on the mechanical dispersion of the product. This report describes the use and the limitations of a new method capable of significantly reducing or preventing gelation by the simple addition of sucrose.

## MATERIAL AND METHODS

Fresh papaya puree was prepared as follows: Ripe solo papayas obtained from the fields of Waimanalo Experimental Farm were butted and halved, and the seeds were scooped out with a spoon. The fruits were then pureed either by dicing them into 1-inch cubes and passing the cubes through a Langsenkamp pulper fitted with an 0.020-inch screen, or by scooping out the the flesh with a spoon and passing only the flesh through the pulper. These two types of puree will be referred to hereinafter as Type A and Type B, respectively.

The gel strength of papaya puree was measured by an instrument developed especially for this purpose. The instrument consists of an Ohaus triple beam balance, modified by attaching a plunger, consisting of a stiff metal rod (length, 24 cm) and disc (diameter, 1.9 cm), to the vertical shaft below the pan. The gel strength was measured by slowly raising the sample, by means of a laboratory jack, until contact was made with the disc and then continuing to raise the sample until the beam was displaced to its maximal position. While the beam was arrested at this position, weights were placed on the pan. The beam was then released. The gel strength is indicated by the number of grams required to cause just a smooth, even swing of the pointer from the lower to the upper end of the scale. A new surface of the sample was used for each trial determination.

## RESULTS

### *The Gelation Phenomenon*

The nature of gelation in frozen papaya puree has not previously been demonstrated. It seemed desirable, therefore, to describe the phenomenon clearly. Earlier work on the control of the gelation phenomenon suggests that the gelation involves enzymatic activity and pectin. Type A puree was prepared, distributed into No. 2 cans, and treated as outlined in table 1. The samples were sealed, then frozen and stored for 1 week at 0°F. The samples were thawed by immersion in tap water for 2 hours and then the contents were examined. The results, as shown in table 1, suggest that gelling of frozen papaya puree is due to the formation of a low methoxyl pectin gel resulting from the action of pectin esterase upon papaya pectin.

Table 1. The effect of various treatments on the gelation of frozen papaya puree

| Treatment | None | 0.1% pectinol | Heated to 195° F | Heated to 195° F, cooled, 0.1% pectin esterase* added |
|---|---|---|---|---|
| Observations after thawing | Firm gel | Fluid | Coarse, lumpy | Firm gel |

*Obtained from a commercial source.

Specific activity: 16 milliequivalents of ester hydrolyzed per minute per gram of enzyme *(1)*.

### *Effect of Sucrose on Gelation of Frozen Papaya Puree*

Preliminary experiments suggested the possibility of using sucrose as a gelation inhibitor. To observe the effectiveness of sucrose as a gelation inhibitor, Type A puree was prepared and sucrose in 13% concentration was added to half of the puree. The samples were distributed into 6 oz cans, and then frozen and stored at 0° F. Samples were thawed and examined after periods of 2, 4, 8, and 14 weeks' storage. After 2 weeks' storage, the sample without added sucrose was firmly gelled. This sample retained its shape and showed considerable syneresis after its removal from the can. Samples

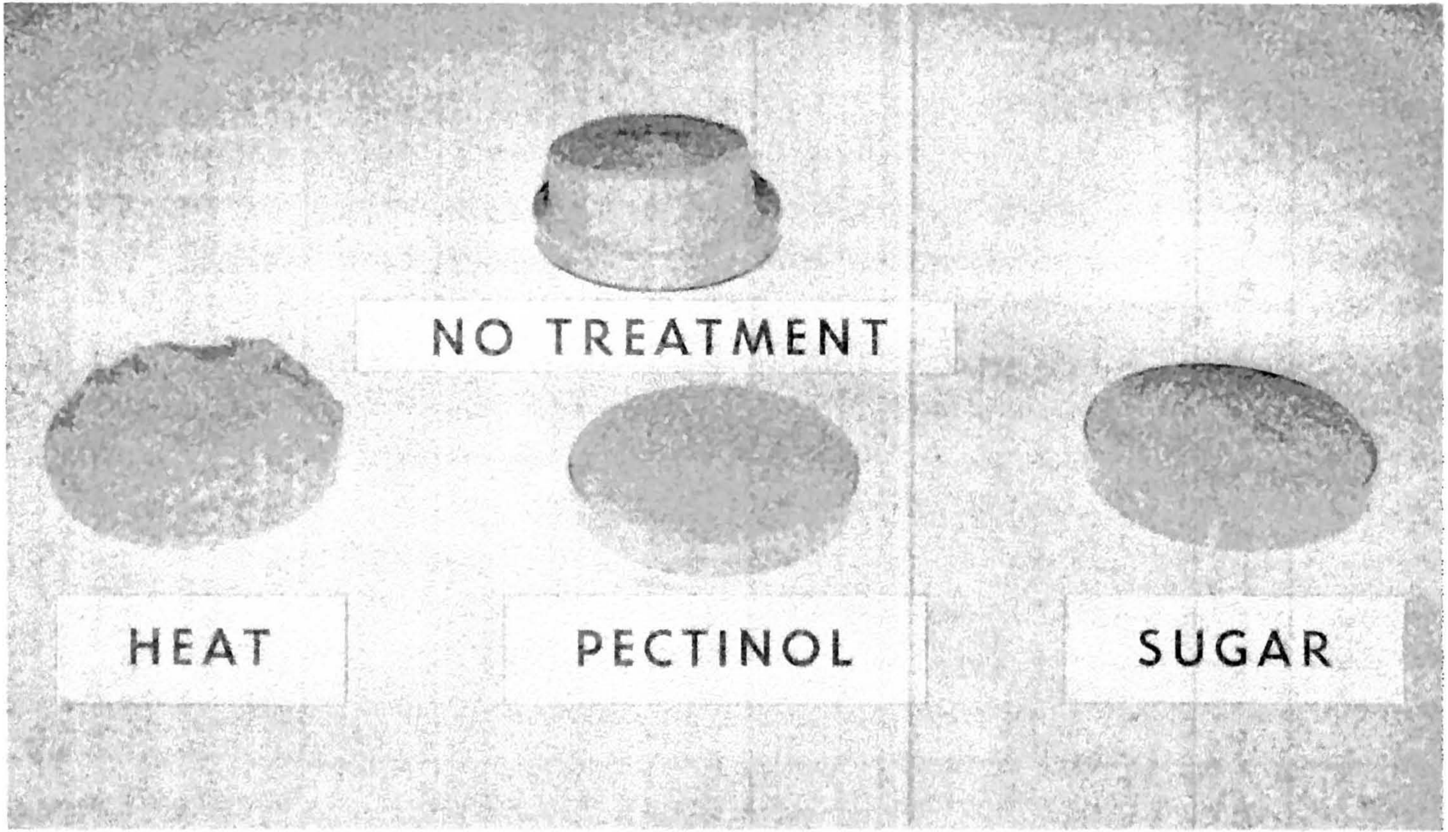


Figure 1. Three methods of gel control.

without added sugar examined at later periods showed a similar gelled condition. Samples containing added sucrose after 2 and 4 weeks' frozen storage remained free flowing and smooth in texture. After 8 and 14 weeks' storage, the samples remained free flowing but were slightly coarse in texture.

Figure 1 shows the results of applying the three methods of gel control on a Type A puree. The samples were frozen and stored for 24 hours at 0° F.

*Effect of Sucrose on Gelation of Papaya Puree at 36° F*

It was of interest to determine whether or not sucrose would have an inhibitory effect on gel development in unfrozen samples. In order to minimize the influence of microbial activity, 36° F was selected as the incubation temperature. Samples of Type B puree, at ambient temperature, containing 0, 7, and 13% sucrose, were placed in the cold room. The gel strength and temperature were followed for 42 hours. The samples attained incubating temperature within 6.3 hours. Figure 2 shows that sucrose inhibits gel development even in unfrozen samples. As a guide, a sample with a gel reading of 17 just begins to retain its shape when carefully removed from the container. It should be emphasized that although sucrose inhibits gelation it does not completely prevent gel development. The immediate practical significance is that even in process operations where papaya puree is prepared and processed to final form without a holding stage of frozen storage, the early addition of sucrose will keep the puree smooth and fluid for a greater length of time and should therefore contribute to an improved finished product.

*Influence of Processing Conditions on the Effectiveness of Sucrose as a Gelation Inhibitor of Frozen Papaya Puree*

The influence of processing conditions in the gelation of frozen papaya puree is well recognized. Seagrave-Smith and Sherman *(2)* reported gelling to be influenced by the rpm at which a pulper is operated. In the present work, the influence resulting from the inclusion of skin material was apparent. When puree Types A and B were prepared and immediately frozen without further treatment, Type A puree invariably thawed out as a gel, but Type B puree, although slightly coarse in texture, thawed out as a fluid.

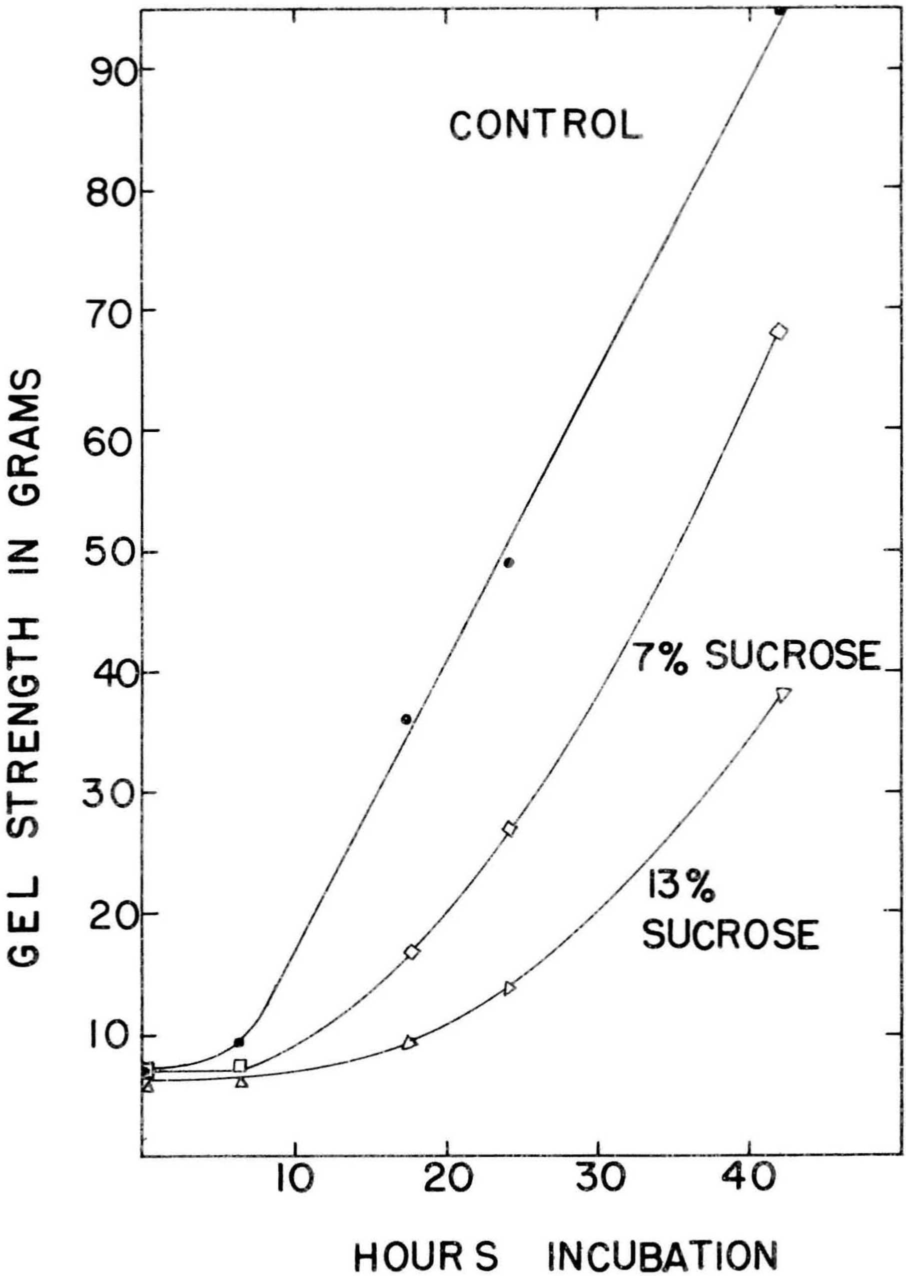


Figure 2. Gelation at 36° F.

The effects of time-of-sucrose-addition and time-interval from pureeing to freezing were investigated. Type B puree was prepared. The puree was then separated into two sets. In Set I, 7% and 13% sucrose were added immediately after pureeing. The puree was then distributed half-full into No. 2 cans. At 1, 2, 3, 5, and 7 hours after this preparation, representative samples were placed into frozen storage of 0° F. In Set II, the puree was first distributed into No. 2 cans, and the addition of sucrose was delayed until just prior to placing the cans in frozen storage. A control sample without added sucrose was also included. Time treatments were as indicated for Set I. Prior to being placed in the freezer, all samples were stirred an equal number of times. The samples were thawed after 2 days' storage.

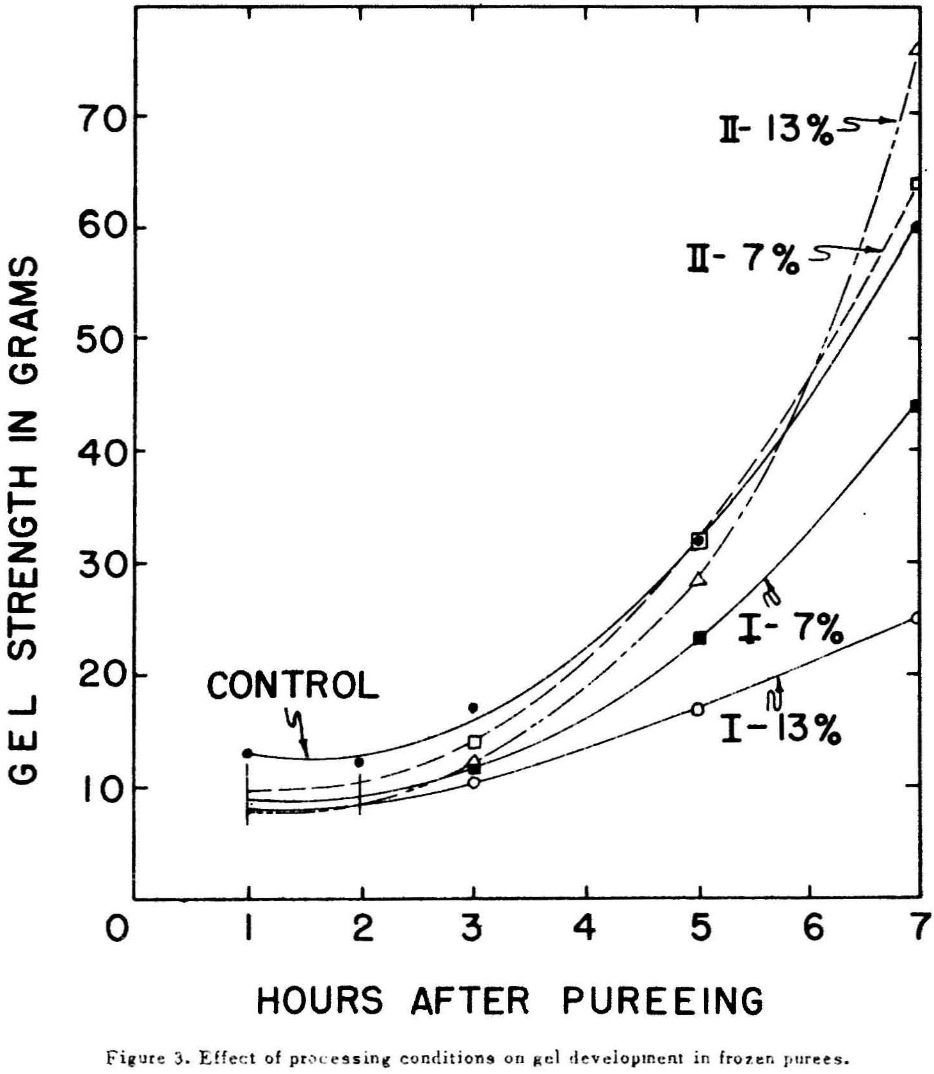


Figure 3. Effect of processing conditions on gel development in frozen purees.

For Set I, figure 3 shows that the rate of gel development in the thawed samples containing sucrose was appreciably slower than the rate for the control without sucrose. For Set II, the effectiveness of sucrose in inhibiting gel development was very much reduced or even questionable in all samples. After a 5-hour delay in sugar addition, indications were that sucrose did in fact contribute to the development of a firmer gel. The point is clear, then, that the most effective use of sucrose as a gelation inhibitor is made by adding sucrose immediately after the puree is prepared rather than adding it just before placing in frozen storage.

## DISCUSSION

Commercial processing methods vary considerably among the different processors of papaya puree. The methods of processing as well as the variables used in this study were not designed to duplicate any one commercial process but rather to establish principles and guidelines for the processing of papaya puree and in particular, for the use of sucrose as a gelation inhibitor.

Processing variables that influence gelling of papaya puree are: the operating speed of the pulper *(2)*, the degree of incorporation of skin material, the temperature of the puree, and the time required for the entire operation.

The exclusion of as much skin material as practicable is important not only in reducing gelation but also for obtaining papaya puree of the highest organoleptic quality.

Time and temperature factors always are important considerations in food processing. The first step in the gelation phenomenon is enzymatic activity, i.e., where pectin esterase demethylates the pectin. The enzymatic activity where the cellular components become intimately intermixed is promoted by pureeing. A possible explanation for the effect that operating speed of the pulper has on gelling, cited earlier, is that at higher speeds the degree of cellular destruction and mixing is increased. Therefore, the undesirable effects of pectin esterase activity can be minimized by gentle pureeing, by keeping the temperature of the product low, and by rapid processing.

The early addition of sucrose is a primary consideration in the use of sucrose as a gelation inhibitor. Sucrose must be added as soon as practicable after the puree is prepared; preferably within an hour. The sucrose concentration recommended is 13%. Lower concentrations are less effective, but may be suitable in special cases. After thorough mixing, the puree should be placed into frozen storage immediately. Care must be taken to insure that the puree is frozen rapidly. Close stacking of containers or the use of large containers is not advised.

Because of the various methods and variable conditions of commercial papaya processing, it is difficult to make a generalized statement concerning the applicability of this method to any particular process. The suitability of the method can come only from trials in individual operations. The desirable features of the method, however, can be stated: (1) inasmuch as sucrose is often added as one of the ingredients in the final product, it should cause minimal interference with formulations; (2) heat damage is nonexistent; (3) pectin is not totally degraded; and (4) equipment requirements are minimal.

A disadvantage lies in the fact that sucrose inhibits but does not completely prevent gelation. Since pectin esterase remains active, adequate precautions must be exercised for the successful application of sucrose as a gelation inhibitor.

Finally, it is appropriate to discuss the mechanism by which sucrose inhibits gelation. There are two possible explanations. First, sucrose may physically interfere with the development of the gel structure. Second, sucrose may reduce the activity of the pectin esterase by an inhibitory effect on this enzyme or by a protective effect on the substrate. Evidence clearly pointing to one or both of these possible explanations has not yet been obtained.

## SUMMARY

The gelling of papaya puree is the result of pectin esterase acting upon pectin. Gelling is increased by the inclusion of skin material.

Sucrose in 7 and 13% concentrations was found to be an inhibitor of the gelation phenomenon both in samples kept at 36° F and when samples were frozen and then thawed. For samples frozen and stored at 0° F, sucrose was most effective when added within 1 hour after pureeing. Samples processed with skin and added sucrose remained fluid even after 4 months' storage at 0° F.

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UNIVERSITY OF HAWAII
COLLEGE OF TROPICAL AGRICULTURE
HAWAII AGRICULTURAL EXPERIMENT STATION
HONOLULU, HAWAII